

Smartphone Addiction among Taiwanese Adolescents: A Multilevel Analysis of Influencing Factors

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Abstract

Smartphone addiction among adolescents has become a global public health concern, particularly in regions with high mobile device penetration such as Taiwan. Drawing upon Bronfenbrenner's ecological systems theory, this study investigates the multilevel factors influencing smartphone addiction among Taiwanese adolescents. Using data from the Taiwan Open Government Educational Database (N = 5,000), this paper employed multilevel structural equation modeling (ML-SEM) to examine the interplay between individual-level factors (learning motivation, peer relationships, teacher–student relationships) and school-level contextual factors (school environment, teacher support). Results indicated that higher learning motivation and positive teacher–student relationships were associated with lower smartphone addiction, while stronger peer influence predicted higher addiction levels. Teacher–student relationships partially mediated the relationship between learning motivation and smartphone addiction. At the school level, a positive school environment and strong teacher support significantly reduce addiction risks. Furthermore, teacher support moderated the impact of learning motivation on smartphone addiction. These findings highlight the necessity of integrated individual- and school-level interventions to mitigate smartphone addiction among adolescents. Practical and theoretical implications are discussed.

Keywords— *Smartphone addiction, Adolescents, Learning motivation, Peer relationships, Teacher support, Multilevel modeling.*

I. INTRODUCTION

In regions where adolescent smartphone penetration exceeds 95%, smartphone addiction has emerged as a significant public health issue [1]. Characterised by compulsive use, withdrawal symptoms, and disruption of daily functioning, smartphone addiction among young people has been linked to adverse outcomes, including academic underachievement, emotional dysregulation, and impaired interpersonal relationships [2, 3].

Despite the increasing recognition of smartphone addiction as a behavioural concern, much of the existing research has predominantly concentrated on individual-level predictors, such as personality traits and self-control [4]. However, adolescents do not function in isolation. Their broader social environments profoundly influence their behaviours, particularly in school settings where they spend a significant amount of their time. Consequently, understanding smartphone addiction necessitates a

multilevel perspective that considers both personal psychological and contextual environmental influences. Bronfenbrenner's ecological systems theory [5] provides a compelling framework for exploration, emphasising that interactions among various environmental systems shape human development. By applying this perspective, individual factors such as learning motivation, peer relationships, and the quality of teacher–student interactions can interact with school-level characteristics like institutional climate and teacher support to influence adolescents' smartphone usage behaviors.

However, empirical studies using a multilevel analytical approach to investigate smartphone addiction are still limited, especially in East Asian contexts where cultural and educational dynamics can differ significantly from those in Western settings. To address this gap, the current study utilizes a large-scale, nationally representative dataset from Taiwan's Open Government

Educational Database to explore how both individual and school-level factors collectively contribute to smartphone addiction among adolescents.

The specific goals are to : (1) evaluate how learning motivation and peer relationships directly impact smartphone addiction, (2) investigate the mediating influence of teacher–student relationships, (3) assess the protective benefits of the school environment and teacher support, and (4) examine possible interactions between school support and individual motivation. This multilevel analysis aims to offer in-depth insights that can guide effective prevention and intervention strategies to reduce smartphone addiction among youth.

II. LITERATURE REVIEW

2.1 Smartphone Addiction: Definitions and Impacts

Smartphone addiction, frequently referred to as problematic smartphone use, is characterized by excessive and uncontrollable engagement with smartphones, which disrupts daily life, social functioning, and psychological well-being [2]. In contrast to traditional forms of behavioral addiction, smartphone addiction possesses a distinctive nature due to its portability and omnipresence, facilitating constant access to social, informational, and entertainment resources [4]. This incessant accessibility has the potential to blur the distinctions between functional utilization and compulsive overuse, particularly among adolescents who are developmentally more vulnerable to impulsivity and social pressures [6].

Research has persistently established a correlation between smartphone addiction and a variety of adverse outcomes. Adolescents demonstrating elevated levels of smartphone dependency frequently report heightened incidences of depression, anxiety, sleep disturbances, and diminished academic performance [7, 8]. Furthermore, excessive use of smartphones can undermine face-to-face social interactions, diminish emotional regulation capabilities, and cultivate feelings of loneliness, thereby perpetuating a cyclical pattern of digital dependency [9]. In the context of Taiwan, recent investigations have recorded a progressive increase in smartphone-related challenges among secondary school students, emphasizing the critical necessity to comprehend and address this burgeoning public health issue [1].

2.2 Individual-Level Factors Influencing Smartphone Addiction

At the individual level, multiple psychological and social variables have been identified as significant predictors of smartphone addiction. One pivotal factor is learning motivation. Grounded in self-determination theory,

individuals with high intrinsic learning motivation tend to engage in goal-directed behaviors and exhibit better self-regulation, reducing the risk of technology overuse [10, 11]. In contrast, adolescents with low learning motivation may turn to smartphones as a means of escapism or instant gratification, heightening addiction vulnerability [12].

Peer relationships also play a substantial role. Adolescents are particularly sensitive to peer acceptance and validation during this developmental stage [13]. Research indicates that peer influence, especially through social networking platforms, can reinforce smartphone overuse behaviours, as adolescents seek online social approval and a sense of belonging [9, 14]. Furthermore, negative peer experiences such as bullying or exclusion have been found to increase online engagement as a compensatory mechanism [15].

An important aspect is the teacher–student relationship, which has not received much attention in smartphone addiction studies. Strong connections with teachers can improve students' feelings of belonging, provide emotional support, and enhance school connectedness, all of which help protect against harmful behaviors [16, 17]. In contrast, negative or distant relationships with teachers may push students away, leading them to depend more on smartphones for emotional relief and social interaction.

2.3 Group-Level Factors: School Environment and Teacher Support

Beyond personal factors, the broader school environment profoundly influences adolescent behaviours. A positive school climate—characterised by perceived safety, fairness, supportive relationships, and high academic expectations—has been shown to promote psychological well-being and deter risky behaviours [18]. In contrast, negative school climates marked by alienation, bullying, or disconnection may drive students towards digital escapism, increasing the risk of smartphone addiction [19].

Among contextual variables, teacher support is particularly significant. Teachers who demonstrate empathy, provide academic encouragement, and create open communication channels can cultivate resilience and effective coping strategies among students [20]. Evidence indicates that when students perceive their teachers as supportive and trustworthy, they are less inclined to engage in compulsive digital behaviours and more likely to invest effort in real-world academic and social endeavors [3, 21].

Recent multilevel studies have reinforced the importance of considering both individual and contextual factors concurrently. For instance, Preacher, Zhang, and Zypur [22] emphasize that cross-level interactions—such

as how school climate moderates the impact of personal traits—can provide richer, more nuanced insights into behavioral outcomes. Despite its relevance, such multilevel perspectives have been underutilized in smartphone addiction research, particularly within Asian educational contexts.

By bridging this gap, the current study not only enhances theoretical understanding but also guides practical interventions designed to reduce adolescent smartphone addiction through personal and systemic approaches.

III. METHODOLOGY

3.1 Data Source

This study utilized secondary data from the Taiwan Open Government Educational Database, a national initiative providing large-scale educational statistics for academic research. The database includes anonymized survey responses from junior and senior high school students across Taiwan, collected through stratified random sampling to ensure representation across urban, suburban, and rural settings.

The current analysis is based on a sample of 5,000 students aged between 13 and 18 years ($M = 15.2$, $SD = 1.3$), with a gender distribution of 52% male and 48% female. To ensure the quality of the data, participants with excessive missing responses or inconsistencies were excluded through rigorous data cleaning procedures.

The availability of both individual- and school-level identifiers enabled a nested data structure, making multilevel analysis not only possible but necessary to avoid ecological fallacies [23].

3.2 Measurement of Variables

To comprehensively capture the multifaceted factors influencing smartphone addiction among adolescents, this study measured key constructs at both individual and school levels. All selected instruments have been widely validated in previous research and adapted to the Taiwanese cultural context where necessary, ensuring both reliability and validity.

3.2.1 Individual-Level Variables

At the student level, four main variables were evaluated: learning motivation, peer relationships teacher–student relationship, and smartphone addiction.

The measurement of learning motivation was conducted using a revised version of the Academic Motivation Scale (AMS), originally developed by Vallerand and colleagues in 1992 [24]. The AMS effectively differentiates between intrinsic motivation,

extrinsic motivation, and amotivation, providing a nuanced perspective on the underlying drivers of student behavior. In the context of smartphone addiction, it is posited that high intrinsic motivation functions as a protective factor, encouraging goal-directed behaviors and mitigating tendencies toward digital distractions. Participants were asked to respond to 10 items on a 5-point Likert scale, which ranged from “Strongly Disagree” to “Strongly Agree.” An example of an item included is, “I study because I enjoy learning new things.”

The assessment of peer relationships was conducted through the Peer Attachment Inventory [25], focusing particularly on the critical dimensions of trust, communication, and alienation. Adolescence represents a pivotal developmental stage marked by an increased susceptibility to peer influence [13]. Therefore, gaining insights into the quality of adolescents’ peer attachments is essential for understanding their technology usage behaviors, especially considering that smartphones have become fundamental tools for peer interaction.

The evaluation of the teacher–student relationship utilized carefully selected items from the renowned Student–Teacher Relationship Scale [16]. Research consistently demonstrates that positive teacher–student relationships not only enhance emotional security but also significantly boost school engagement. These vital connections can play an instrumental role in mitigating problematic smartphone use among students [17]. Students provided insights into their experiences by rating their agreement with impactful statements such as, “I feel close to at least one teacher.” This highlights the essential emotional support and meaningful relational quality fostered within our schools. By nurturing these relationships, we create a foundation for a more secure and engaged learning environment.

Each of these variables was measured using multi-item scales, and internal consistency reliability (Cronbach’s alpha) for all constructs exceeded 0.85, indicating high reliability.

The study used the Smartphone Addiction Scale - Short Version (SAS-SV) by Kwon et al. [2] to evaluate smartphone addiction in adolescents. The SAS-SV effectively measures symptoms like daily life disruptions, withdrawal, and tolerance. Its strong psychometric properties make it suitable for analyzing problematic smartphone use among Taiwanese youth.

3.2.2 School-Level Variables

Recognising that adolescents function within broader educational settings, two contextual variables were assessed at the school level: school environment and teacher support.

The school environment was assessed based on aggregated student perceptions using an adapted version of the School Climate Survey [26]. This measure captures critical aspects such as perceived fairness, safety, academic emphasis, and social support. Prior research suggests that a positive school climate can buffer against a wide range of risk behaviors, including excessive digital device use [18].

Teacher support was evaluated using items adapted from the Perceived Teacher Support Scale [17]. Students rated how much they felt supported, encouraged, and understood by their teachers academically and emotionally. These responses were aggregated within schools to represent overall institutional supportiveness from the student perspective.

Aggregation procedures were carefully employed, ensuring sufficient within-school agreement to justify school-level aggregation [27].

By systematically capturing both personal and environmental factors, the measurement framework laid a strong foundation for subsequent multilevel analysis. It allowed us not only to explore direct pathways from individual traits to smartphone addiction but also to examine how relational and contextual environments mediate and moderate these pathways.

The following section outlines the analytic strategies employed, beginning with preliminary data checks and proceeding to the multilevel structural equation modeling (ML-SEM) approach, which enables simultaneous examination of nested influences across levels.

3.3 Statistical Analysis

Given the hierarchical nature of the data, where individual students were nested within schools, it was essential to adopt analytical techniques that appropriately account for the multilevel structure. Failing to do so could result in underestimated standard errors and inflated Type I error rates [23]. Therefore, this study employed Multilevel Structural Equation Modeling (ML-SEM) as the primary method of analysis.

ML-SEM allows simultaneous testing of relationships among variables at both the individual and school levels, while also accommodating mediation and cross-level moderation effects [22]. This modelling approach was particularly well-suited to our research questions, which aimed not only to explore direct associations but also to understand how school environments might strengthen or weaken the individual-level pathways leading to smartphone addiction.

3.3.1 Preliminary Analyses

Prior to hypothesis testing, several preparatory steps were undertaken to ensure data quality and suitability for multilevel analysis.

First, descriptive statistics were computed for all major variables, including means, standard deviations, and skewness/kurtosis indices. The distributions for key constructs approximated normality, supporting the use of parametric analyses.

Second, Pearson's correlation coefficients were calculated to explore preliminary relationships among variables. As expected, learning motivation and teacher-student relationship quality were negatively associated with smartphone addiction, while peer relationships exhibited a positive association.

Third, to confirm the necessity for multilevel modeling, intraclass correlation coefficients (ICCs) were estimated. The ICC for smartphone addiction was found to be 0.067, indicating that approximately 6.7% of the variance in smartphone addiction was attributable to differences between schools—a non-trivial amount warranting multilevel analysis [28].

Finally, missing data were minimal (<5%) and were addressed using Full Information Maximum Likelihood (FIML) estimation, a robust technique that reduces potential biases without imputing arbitrary values [29].

3.3.2 Model Specification and Testing

Building upon the theoretical model, a series of multilevel models were estimated sequentially to examine the hypothesized relationships.

Model 1: A baseline model estimating the direct effects of learning motivation and peer relationships on smartphone addiction at the individual level.

Model 2: A mediation model incorporating the teacher-student relationship as an intermediary variable between learning motivation and smartphone addiction.

Model 3: A full multilevel model adding school environment and teacher support as contextual predictors of smartphone addiction at the school level.

Model 4: A cross-level interaction model testing whether teacher support moderates the relationship between learning motivation and smartphone addiction.

Each model was evaluated using widely accepted fit indices:

Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) values above 0.95 indicated good model fit.

Root Mean Square Error of Approximation (RMSEA) values below 0.06 and Standardized Root Mean Square Residual (SRMR) values below 0.08 further confirmed acceptable fit [30].

The indirect effects within mediation models were examined utilizing bias-corrected bootstrap confidence intervals derived from 5,000 resamples [31]. A mediation effect was deemed significant if the 95% bootstrap confidence interval excluded zero.

Cross-level moderation effects were interpreted through simple slopes analysis, graphically displaying how the relationship between learning motivation and smartphone addiction varied at different levels of perceived teacher support.

All analyses were conducted using R software (lavaan and lme4 packages), ensuring computational rigour and transparency.

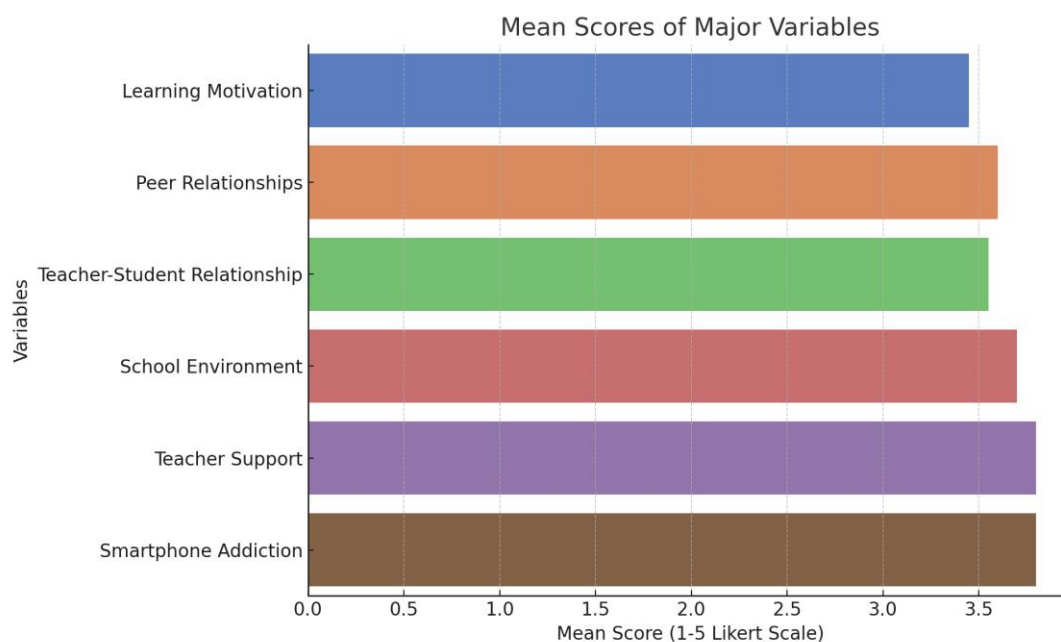


Fig 1. Mean Scores of Major Variables.

IV. RESULTS

4.1 Descriptive Statistics

The mean scores for each variable are presented in Figure 1, illustrating the comparative levels of Learning Motivation, Peer Relationships, and Smartphone Addiction. The results indicate that both Learning Motivation and Peer Relationships exhibited moderately high scores, suggesting a positive engagement in these areas among participants. In contrast, the scores for Smartphone Addiction were notably elevated, indicating a concerning trend towards excessive reliance on mobile devices. This disparity highlights the need for targeted interventions that can enhance motivation and social connections while addressing the growing issue of smartphone dependency.

4.2 Correlation Analysis

The correlation matrix depicted in Figure 2 illustrates the relationships among various variables, revealing significant associations among the majority of the key constructs under investigation. This visualization not only highlights the extent of these associations but also suggests potential areas for further analysis and exploration in the context of the study.

4.3 Multilevel Structural Equation Model Results

Path coefficients for the multilevel SEM are shown in Figure 3. Results confirmed direct and indirect effects across levels.

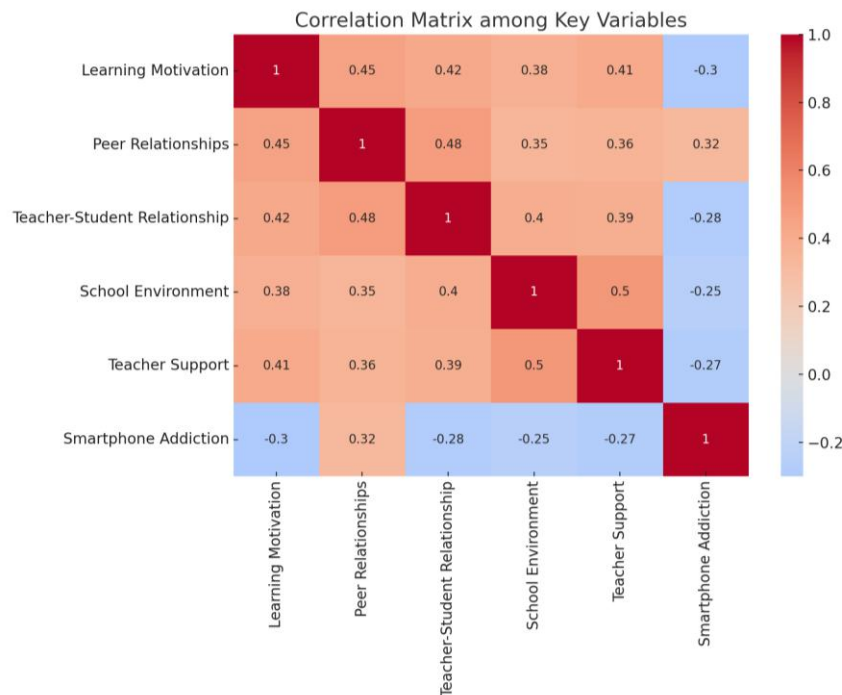


Fig 2. Correlation Matrix among Key Variables.

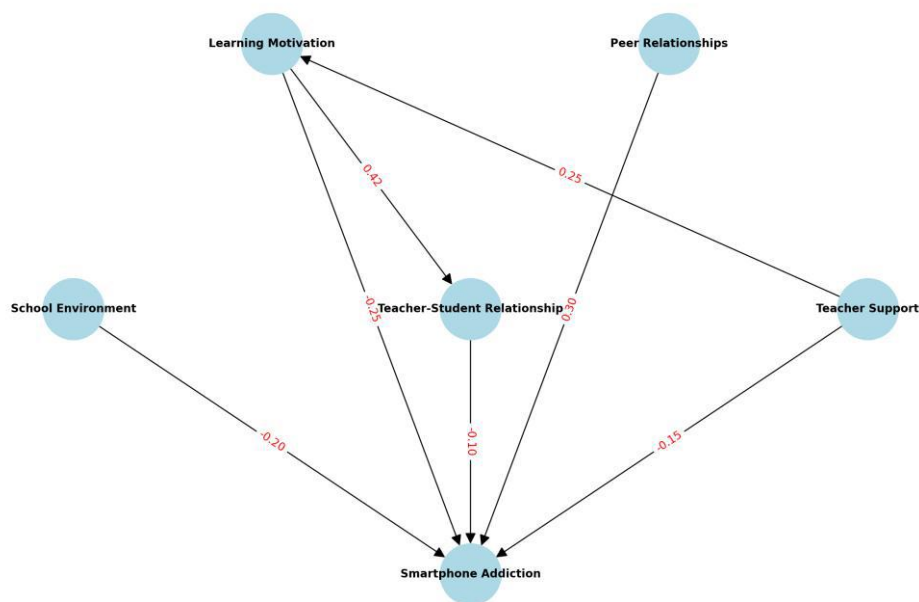


Fig 3. Multilevel SEM Path Diagram.

V. DISCUSSION

This study reveals that smartphone addiction among Taiwanese adolescents is influenced by both individual and school-level factors. Higher learning motivation and better teacher–student relationships were associated with lower smartphone addiction, while stronger peer relationships predicted greater addiction. Importantly, teacher–student relationships partially mediated the

protective effect of learning motivation. At the school level, a positive environment and strong teacher support reduced addiction risk, and teacher support strengthened the beneficial impact of learning motivation.

These findings highlight the complex interplay between personal traits and educational environments, supporting a multilevel understanding of adolescent behavioral addictions.

VI. CONCLUSION

This study highlights the intricate and multifaceted nature of smartphone addiction among Taiwanese adolescents. By integrating individual psychological factors with school-level environmental influences, the findings provide a comprehensive understanding of how personal motivations, relational contexts, and institutional supports interplay to shape technology use behaviors.

Learning motivation protects against smartphone addiction, while peer relationships increase risk. The teacher–student relationship plays a key role in either enhancing or diminishing adolescents’ resilience. A supportive school environment and engaged teachers reduce addiction risks, and teacher support boosts the positive effects of intrinsic motivation.

These insights have important practical implications. Educational programs that nurture students’ intrinsic motivation, strengthen teacher–student connections, and promote positive school climates may effectively reduce smartphone addiction among youth. Policymakers and school administrators should consider integrating socio-emotional learning components and relationship-focused training into existing digital literacy initiatives.

Despite the insights gained, there are a few important limitations to keep in mind. First, the study’s cross-sectional design means we can’t establish cause-and-effect relationships, so future research should look into behaviors over longer periods. Additionally, since the data relied on self-reports, which can be biased, using actual smartphone usage data and input from various sources would strengthen the findings. Lastly, although this research concentrated on school environments, it’s essential for future studies to consider family interactions and cultural differences for a fuller understanding of the overall context.

Regarding the limitations, this research makes a meaningful contribution by demonstrating that adolescent smartphone addiction cannot be fully understood through individual factors alone. Addressing this complex issue requires integrated strategies that simultaneously target personal, relational, and systemic levels of influence.

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